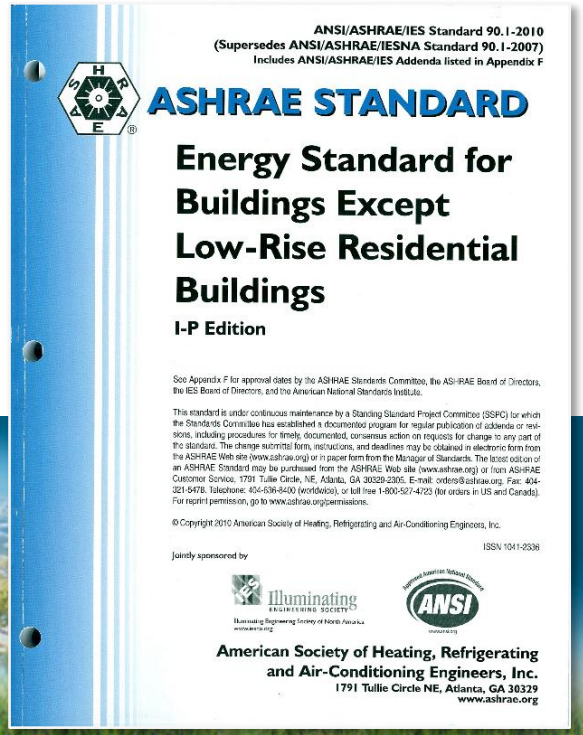
ANSI / ASHRAE / IESNA Standard 90.1 – 2010

Part 4 – Mechanical Provisions
HVAC continued, Water Heating, Power & Motors
(Sections 6, 7, 8, 10)



Presented by

Energy Systems Laboratory
Texas Engineering Experiment Station
The Texas A&M University System

Presenter

Larry O. Degelman, P.E.
Professor Emeritus of Architecture, Texas A&M University

Acknowledgments

Thanks to:

- The American Recovery & Reinvestment Act (ARRA)

- Department of Energy (U.S.DOE)

- Texas State Energy Conservation Office (SECO)

Simultaneous Heating & Cooling Limitation

Section 6.5.2.1 (Zone Controls)

- Zone controls capable of operating in sequence the supply of heating and cooling energy to the zone to prevent:
  a. reheating,
  b. recooling,
  c. mixing or simultaneously supplying air previously heated or cooled
  d. Other simultaneous operations of heating and cooling systems to the same zone.
- Hydronic system controls to prevent reheating or re-cooling of fluids.

Zone Controls - Exceptions

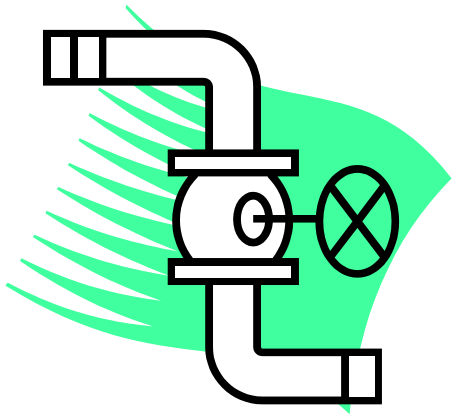
Section 6.5.2.1

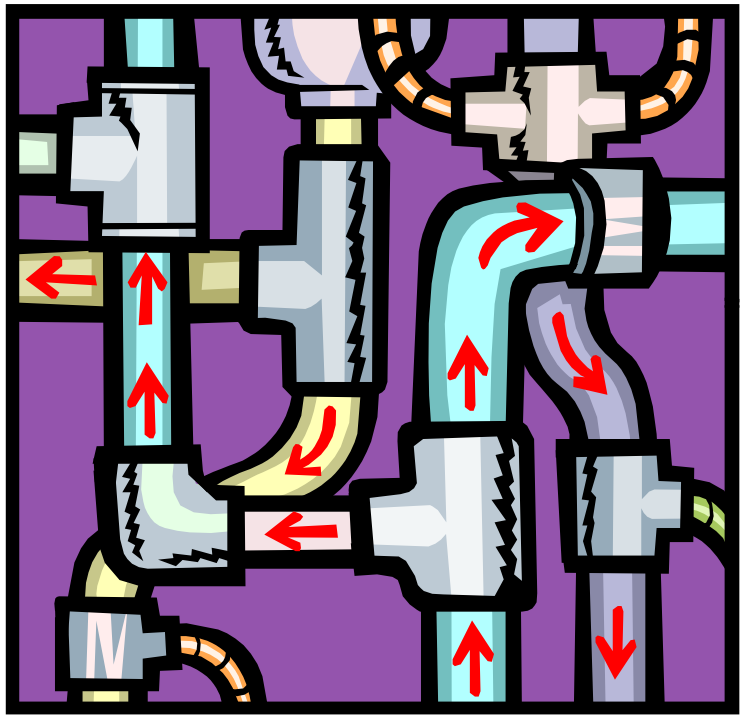
- **Zones for which volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:**
  1. **30% of zone design peak supply.**
  2. **Volume of outside air to meet Section 6.2 of ASHRAE 62.1 for the zone.**
  3. **Any higher rate that will reduce the overall system annual energy usage by offsetting the reheat/recool energy losses by a reduction in OA.**
  4. **The air flow rate required to comply with applicable codes or accreditation standards.**
- **Zones that comply with all the following:**
  1. **Air flow in the dead band ≤ 20% of peak supply rate, or OA rate ≤ ASHRAE 62.1 requirements, or can be modulated.**
  2. **Mixed air flow rate < 50% of zone peak supply rate.**
- **Lab exhaust systems that comply with Section 6.5.7.2, regarding preconditioning of makeup air from lab exhaust air.**
- **Zones where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a *site-recovered* or *site- solar energy source*."**

Three-pipe Hydronic System

Section 6.5.2.2.1

- That's a NO-NO!
- No common return system for both hot and chilled water.





Two-pipe Changeover System

Section 6.5.2.2.2

- **Common (2-pipe) distribution system acceptable if all the following are met:**
  - **a. Dead band from one mode to another is ≥ 15°F outside air temperature, and**
  - **b. Controls designed to allow operation of ≥ 4 hours before changing over, and**
  - **c. Reset controls are provided that allow heating and cooling supply temperatures at changeover point to be ≤ 30°F apart.**

Dehumidification

Section 6.5.2.3

"Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream."

Exceptions:

a. System is capable of reducing SA volume to 50% of design airflow rate or the ventilation rate required in Standard 62.1.
b. The individual cooling unit has a design cooling capacity ≤ 80,000 Btu/h and capable of unloading to 50%.
c. The individual FCU has a design cooling capacity ≤ 40,000 Btu/h.
d. Where specific humidity levels are required, such as vivariums, museums, surgical suites, buildings with refrigerating units like supermarkets, refrigerated warehouses, and ice arenas. (Does not apply to computer rooms)
e. At least 75% of the energy for reheating or warming air for mixing is provided from a site-recovered or site-solar energy source.
f. Systems where the heat added to the airstream is the result of use of a desiccant system and 75% of the heat added is removed by a heat exchanger.

Fan Power Limitation

Options 1 & 2, Section 6.5.3.1.1

Table 6.5.3.1.1A Fan Power Limitation #

Option	Limit	Constant Volume	Variable Volume
1	Allowable Nameplate hp	$hp \le CFM_S \times 0.0011$	$hp \le CFM_S \times 0.0015$
2	Allowable Fan system bhp	$bhp \le CFM_S \times 0.00094 + A$*	$bhp \le CFM_S \times 0.0013 + A$*

* Adjustment (A) = $\sum (PD_i \times CFM_i / 4131)$, where:

PD_i = pressure drop (" w.c.) adjustment for each "i"component in Table 6.5.3.1B (next slide), and

CFM_i = CFM through component "i"

\# Compute "installed bhp" = $\sum [PD_j \times CFM_j / (6356 \times \eta_j)]$, where:

PD_j = pressure drop (" w.c.) across fan system "j"

CFM_j = CFM of fan system "j"

η_j = efficiency of fan system "j" (assumed to be 0.65 allowable limits)

Footnote: This methodology was first introduced in Standard 90.1-2007, though with different adjustment values.

Fan Power Limitation

Option 2 - Section 6.5.3.1.1

Table 6.5.3.1.1B for the brake horsepower (bhp) option 2 Adjustment Factors (A)

TABLE 6.5.3.1.1B Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	0.5 in. w.c. (2.15 in. w.c. for laboratory and vivarium systems)
Return and/or exhaust airflow control devices	0.5 in. w.c.
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	0.5 in. w.c.
Particulate Filtration Credit: MERV 13 through 15	0.9 in. w.c.
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy Recovery Device, other than Coil Runaround Loop	(2.2 × Energy Recovery Effectiveness) – 0.5 in w.c. for each airstream
Coil Runaround Loop	0.6 in. w.c. for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound Attenuation Section	0.15 in. w.c.
Exhaust system serving fume hoods	0.35 in. w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 in. w.c./100 ft of vertical duct exceeding 75 ft

Part-load Fan Power Limitation

Section 6.5.3.2.1

- **Individual VAV fans with motors ≥ 10 hp ***
  - **Shall have VSD, or**
  - **Shall be vane-axial w/ variable pitch blades, or**
  - **Shall have other controls and devices to result in fan motor demand ≤ 30% of design wattage at 50% of design air volume when static pressure set point = 1/3 of total design static pressure, based on *manufacturer's* certified fan data.**

*** Was 30 hp in 90.1-2001 and 15 hp in 90.1-2004.**

Exhaust Air Energy Recovery

Section 6.5.6.1

- **Incorporate exhaust air energy recovery systems with at least 50% enthalpy energy recovery effectiveness.**

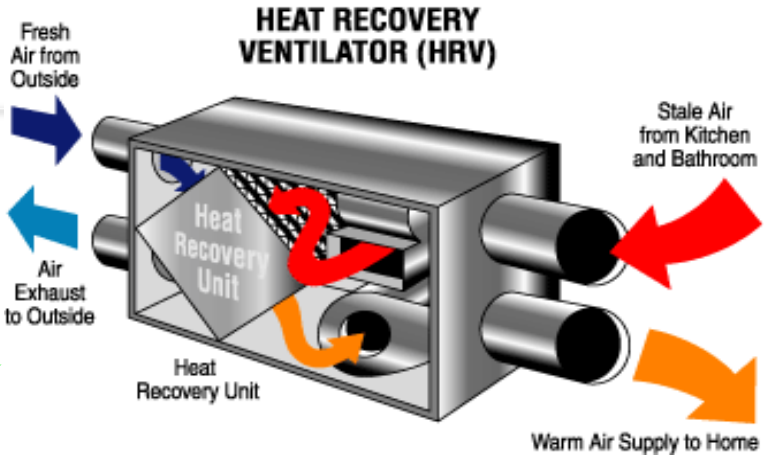


Table 6.5.6.1 Exhaust Air Energy recovery Requirements

Climate Zone	% Outdoor Air at Full Design Airflow Rate					
	30-40%	40-50%	50-60%	60-70%	70-80%	> 80%
	Design Supply Fan Airflow Rate (cfm)					
3bc,4bc,5b	NR	NR	NR	NR	≥5000	≥5000
1b,2b,5c	NR	NR	≥26000	≥12000	≥5000	≥4000
6b	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
1a-6a	≥5500	≥4500	≥3500	≥2000	≥1000	>0
7,8	≥2500	≥1000	>0	>0	>0	>0

Exceptions to Exhaust Heat Recovery

Section 6.5.6.1

(a) Laboratory fume hoods systems meeting Section 6.5.7.2 (applying to Fume Hoods>5,000 cfm)

(b) Systems serving uncooled spaces and are heated to < 60°F.

(c) Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

(d) Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

(e) Where > 60% of *outdoor air* heating energy is provided from site-recovered or site-solar energy.

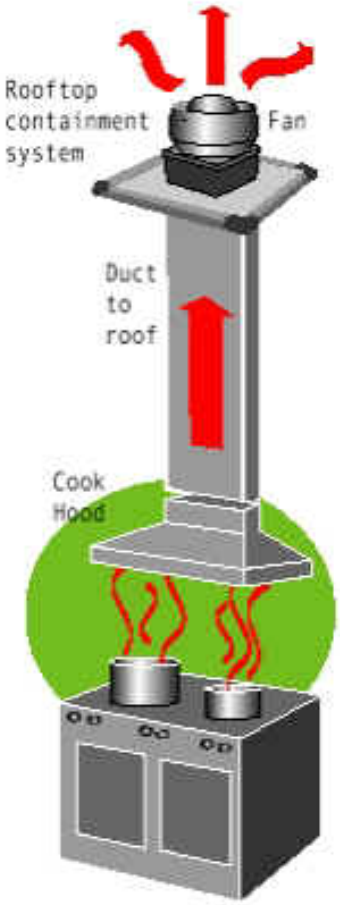
(f) Heating systems in climate zones 1 and 2.

(g) Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, & 8.

(h) Where largest single exhaust source is < 75% of the design *outdoor air* flow.

(i) Systems requiring dehumidification that employ energy recovery in series with the cooling coil.

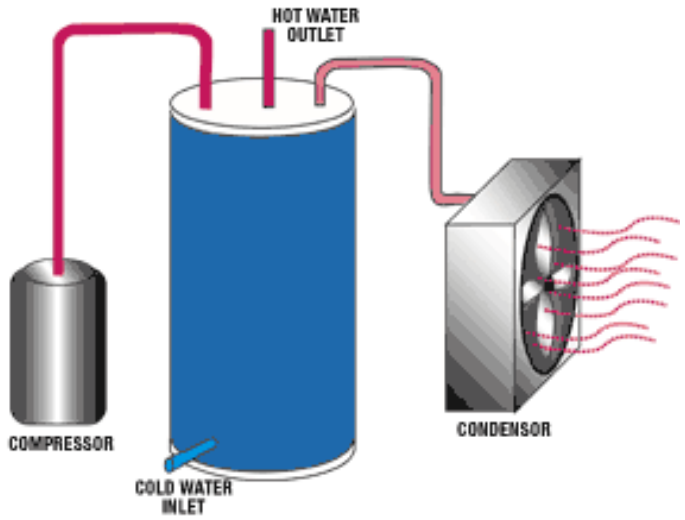
(j) Systems in Table 6.5.6.1 that operate < 20 hrs/week.



Heat Recovery for SWH

Section 6.5.6.2

- **Condenser recovery required for service water heating if:**
  - **Used 24 hours per day and**
  - **Heat rejection > 6,000,000 Btu/h (approx. 375 tons) and**
  - **SWH load > 1,000,000 Btu/h**



Completion Requirements

Section 6.7.2

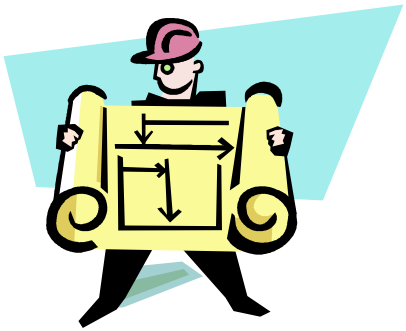
- Record drawings
- Operating and maintenance manuals
- System balancing
- System commissioning

Record Drawings

Section 6.7.2.1

Record drawings of actual installation to building owner within 90 days of system acceptance and include, as a minimum:

- "Location and performance data on each piece of equipment
- General configuration of duct and pipe distribution system including sizes
- Terminal air or water design flow rates"



Manuals

Section 6.7.2.2

Operating and maintenance manuals to building owner within 90 days of system acceptance and include, as a <u>minimum:</u>

a. Equipment size and selected options
b. Operation manuals for each piece of equipment requiring maintenance with actions clearly identified.
c. Names & address of at least one service agency.
d. HVAC Control system maintenance information.
e. A complete narrative of how each system is intended to operate.

System Balancing

Section 6.7.2.3

- **HVAC systems balanced in accordance with standards in Appendix E.**
- **Written report for conditioned spaces > 5000 ft^2.**

System Commissioning

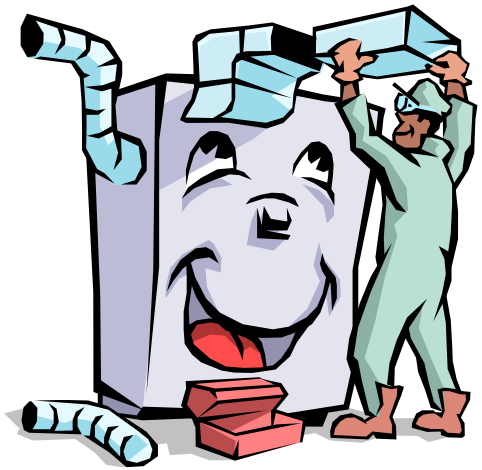
Section 6.7.2.4

- **"Ensure that control elements are calibrated, adjusted, and in proper working condition."**
- **In plans and specs, provide detailed instructions for commissioning of projects > 50,000 ft^2 of conditioned area.**
  - **Except warehouses and semiheated spaces.**

HVAC Alterations

Section 6.1.1.3

- New HVAC equipment, used as a replacement, shall comply w/ minimum efficiencies.
- New cooling systems to serve previously uncooled spaces shall comply with section 6.
- Alterations to HVAC shall not decrease economizer capabilities.
- New & replacement ductwork to comply w/ 6.4.4.1 (insulation) & 6.4.4.2 (leakage).
- New & replacement piping to comply with 6.4.4.1.3 (insulation).



Mechanical Alteration Exceptions

Section 6.1.1.3

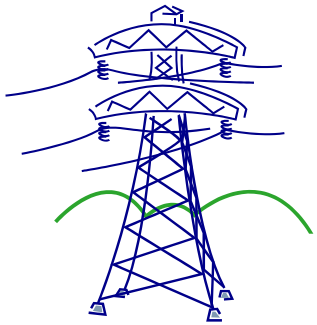
a. Equipment modification or repair only (no increase in energy)
b. Where compliance requires extensive revision to other systems
c. Refrigerant change only
d. Relocation of existing equipment
e. Ductwork, and Piping – where there is insufficient space to access.

SWH, Power & Equipment Provisions

Sections 7, 8 and 10

7. Service Water Heating

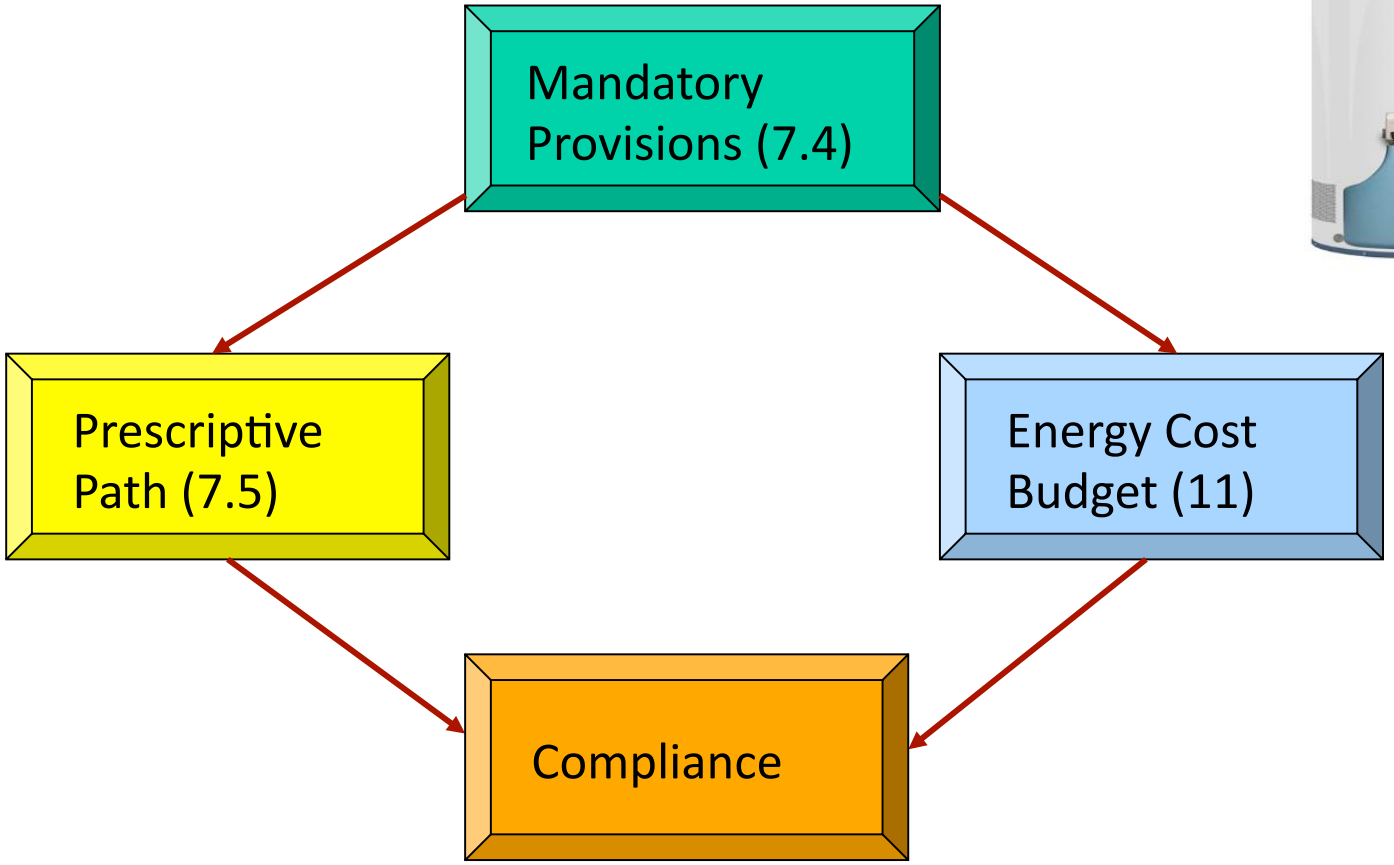
8. Power



10. Other Equipment

Service Water Heating Compliance

Section 7



SWH Equipment Efficiency

Section 7.4.2

- Minimum efficiencies are shown in Table 7.8
- Equipment not listed in Table 7.8 has no minimum performance requirements.
- Exception: Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet ***standby loss*** (SL) requirements when
  - tank surface is thermally insulated to R-12.5, **and**
  - a standing pilot light is not installed, **and**
  - gas- or oil-fired water heaters have a flue damper or fan-assisted combustion."

Water Heating Equipment Performance Requirements Table 7.8

This is a partial segment of Table 7.8

Equipment Type	Size Category	Sub-category or Rating Condition	Performance Required, (EF=Efficiency Factor SL=Standby Losses)
Gas Storage Water Heaters	≤ 75,000 Btu/h	≥ 20 gallons	0.67-0.0019V (EF)
	> 75,000 Btu/h	< 4000 (Btu/h)/gal.	min. 80% E_t & max. [Q/800 + 110 √‾ V] (SL), Btu/h
Hot Water Supply Boilers, Gas		≥ 4000 (Btu/h)/ gal. and ≥ 10 gal.	min. 80% E_t & max. [Q/800 + 110 √‾ V] (SL), Btu/h
Hot Water Supply Boilers, Oil		≥ 4000 (Btu/h)/ gal. and ≥ 10 gal.	min. 78% E_t & max. [Q/800 + 110 √‾ V] (SL), Btu/h
Heat pump pool heater	All	50F DB & 44.2F WB o.a. & 80F entering water.	4.0 COP

Note: Q = nameplate input rating (Btu/h); V = tank volume (gallons); E_t = thermal efficiency

Service H.W. Piping Insulation

Section 7.4.3

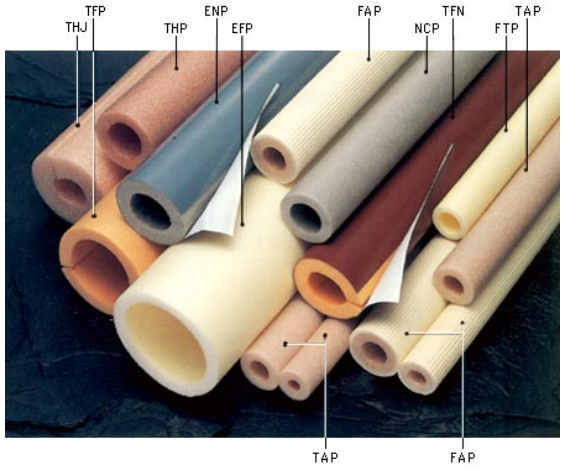
- The following shall comply with Table 6.8.3 in the HVAC Section 6:

a. Recirculating system piping, including supply and return piping.

b. Nonrecirculating storage system --

   1. First 8 ft of outlet piping.
   2. Inlet pipe between storage tank and heat trap.

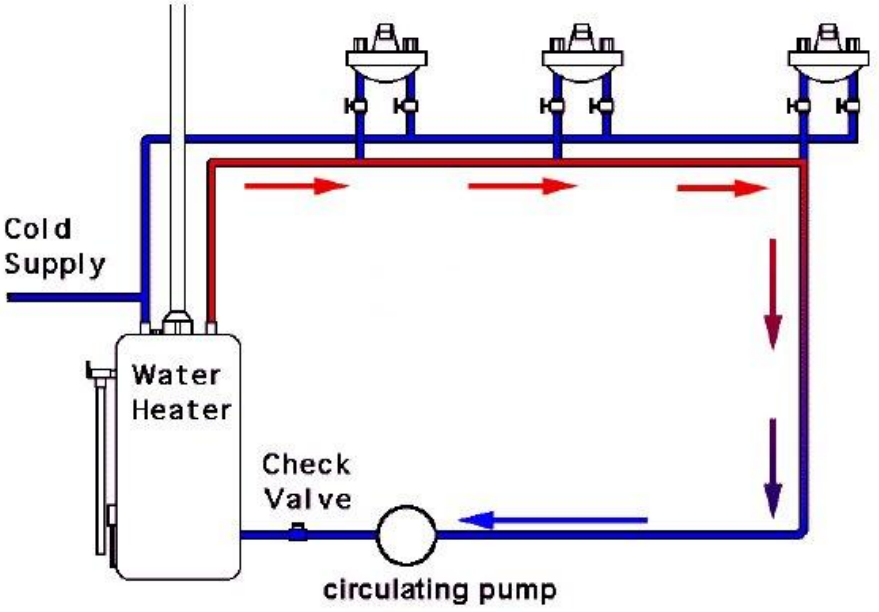
c. Externally-heated pipes (heat trace or impedance heating)



Circulating Pump Controls

Section 7.4.4.4

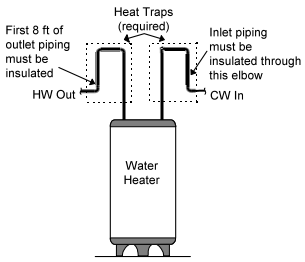
Limit operation to “a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle”



Heat Traps

Section 7.4.6

Non-recirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)



Insulation level per Table 6.8.3

- **Either a device specifically designed for this purpose, or**
- **"Arrangement of tubing that forms a loop of 360°or piping that from the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable".**

Standby Loss Equation

Section 7.5.1

- **Standby loss shall not exceed:**

$$\frac{(13.3 \times pmd + 400)}{n}$$

where,
pmd **is the probable maximum demand in gal/h and** n* **is the fraction of the year when outdoor daily mean temperature is > 64.9°F.**

* ***Note: The parameter "n" is not found in the Climatic Data tables in Appendix D; rather, must be obtained from independent weather sources.***

Power

Section 8

- All mandatory, no prescriptive or alternative paths.
- Voltage drop
- Automatic receptacle shutoff controls
- Completion requirements

Power Transformers

Section 8.1.2 Low Voltage Dry-type Distribution Transformers

Low voltage dry-type transformers shall be NEMA Class I and shall comply with the provisions of the Energy Policy Act of 2005 as shown in Table 8.1.

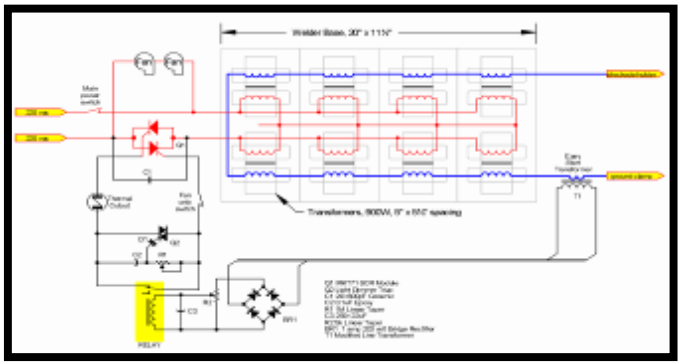
Single Phase Transformers		Three Phase Transformers	
kVA	Efficiency, %	kVA	Efficiency, %
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.7	500	98.7
		750	98.8
		1000	98.9

Voltage Drop

Section 8.4.1

Mandatory Provisions

- **Two types of conductors**
  - Feeder conductors
    - ➢Run between the service entrance equipment and the branch circuit distribution equipment.
    - ➢2% maximum voltage drop allowed.
  - Branch circuit conductors
    - ➢Run from the final circuit breaker to the outlet or load.
    - ➢3% maximum voltage drop allowed.



These requirements are more stringent than non-enforceable requirements in the National Electric Code (NEC.)

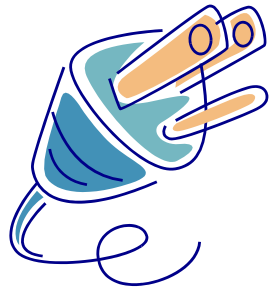
Receptacle Controls

Section 8.4.2

Mandatory Provisions

8.4.2 Automatic Receptacle Control.

At least 50% of all 125-volt, 15-Amp and 20-Amp receptacles, including those in modular partitions, installed in these spaces:



a. Private offices
b. Open offices
c. Computer classrooms

shall be controlled by an automatic control device that shall use:

a) a scheduled basis with time-of-day operated programmable control device – for no more than 25,000 ft^2 and no more than one floor per device, or
b) an occupant sensor that turns receptacles off within 30 minutes of room being vacated, or
c) a signal from another control or alarm that signals the room is unoccupied.

Exceptions:

a) Receptacles for equipment for 24-hour operation.
b) Spaces where automatic shutoff would endanger life safety or security.

Submittals

Section 8.7

Owner gets information about the building's electrical system:

- 8.7.1 Record drawings of actual installation within 30 days.
- 8.7.2 Manuals, similar to those required for the HVAC submittals.

Other Equipment

Section 10.4.1

Mandatory Provisions

Note: All mandatory – no prescriptive or alternative compliance paths.

Section 10.4.1 – Electric Motors

- **Electric motors shall comply with the Energy Policy Act of 1992, as shown in Table 10.8A. Motors not in the scope of EPA have no requirements in this section.**

- **This table plus two additional tables show minimum efficiency for general purpose motors, rated at 600V or less.**

	Minimum Nominal Full-Load Efficiency (%)					
	Open Motors			Enclosed Motors		
Number of Poles ==>	2	4	6	2	4	6
Synchronous Speed (RPM) ==>	3600	1800	1200	3600	1800	1200
Motor Horsepower						
1	-	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

* Nominal efficiencies shall be established in accordance with NEMA Standard MG1.

This Concludes:
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Presenter

Larry O. Degelman, P.E.
Professor Emeritus of Architecture, Texas A&M University

Acknowledgments

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Department of Energy (U.S.DOE)